Army Science Board
FY2013 Summer Study

Final Report
November 2013

Planning for Climate Change: Actions for the Army to Better Adapt to the Effects of Climate Change in 2030

Department of the Army
Office of the Deputy Under Secretary of the Army
Washington, D.C. 20310-0103

DISCLAIMER

This report is the product of the Army Science Board (ASB). The ASB is a Federal Advisory Committee established to provide independent advice to the Secretary of the Army (SA) and the Chief of Staff, Army (CSA). Statements, opinions, conclusions and recommendations contained in this report are those of the ASB and do not necessarily reflect the official position of the United States Army or the Department of Defense.

DEPARTMENT OF THE ARMY
ARMY SCIENCE BOARD
2530 CRYSTAL DRIVE, SUITE 7098
ARLINGTON, VA 22202

DUSA-ASB

October 29, 2013

MEMORANDUM FOR SECRETARY OF THE ARMY

SUBJECT: Final Report of the Army Science Board Study on Planning for Climate Change

1. I am pleased to forward the final report of the Army Science Board entitled, "Planning for Climate Change: Actions for the Army to Better Adapt to the Effects of Climate Change in 2030".

2. As requested by the Terms of Reference, the study was asked to:

- Address how well relevant climate conditions by 2030 can be predicted.
- Assess how expected climate conditions by 2030 might change the way the Army fights, considering all the Title 10 functions.
- Provide recommendations on what the Army needs to consider now to be prepared for the changes that are likely to be manifest by 2030.
- Determine how the Army can ensure that actions it takes in preparation for the world of 2030, are directionally appropriate for climate change conditions that are likely to prevail after 2030.

3. The study team performed this study based on extensive research and discussions across the Department of Defense, including the Army, Navy, Air Force, and Defense Agencies, as well as private sector organizations.

4. The study found that the effects of climate change will grow between now and 2030. Consequently, the training and supplying Title 10 functions for both in the Army generating force and operating force will be impacted. There will be increased need to organize and equip units to meet new and tailored tasks brought about by the effects of climate change. The Army should place more emphasis now on activities and programs necessary to mitigate those effects on the ability of combat units to maneuver and to be reliably supported. Among other tasks, the effects of climate change documented in the study findings need to be codified in the Capabilities Developments Process as they pertain to Army requirements and future capabilities.

5. I endorse the study findings and recommendations.

George T. Singley III
Chairman

CONTENTS

1.0 EXECUTIVE SUMMARY……1
1.1 Preconditions and Assumptions……1
1.2 TOR Questions……1
1.3 Findings……1
1.4 Principal Recommendations……1

2.0 INTRODUCTION AND BACKGROUND……3
2.1 Terms of Reference……4
2.2 Background on Climate Change……5
2.2.1 Climate Change and Fragile Countries……10
2.3 Visits and Study Team Approach……12

3.0 FINDINGS AND ANALYSES……13
3.1 Changes to the Way the Army Fights and Accomplishes Title 10 Missions……13
3.1.1 Narrow Fight: How the Army Fights……14
3.1.2 Broad Fight: Other Primary Missions……15
3.1.3 Title 10 Functions……16

4.0 SUMMARY OF FINDINGS AND RECOMMENDATIONS……18
4.1 Summary of Findings……18
4.2 Principal Recommendations……20
4.2.1 Recommendation 1……20
4.2.2 Recommendation 2……20
4.2.3 Recommendation 3……21
4.2.4 Recommendation 4……22
4.2.5 Recommendation 5……22
4.2.6 Recommendation 6……22
4.2.7 Recommendation 7……23
4.3 Way Forward From Science and Technology……23
4.3.1 Unmanned VTOL Support……24

5.0 APPENDICES……26
Appendix A: Terms of Reference Document……26
Appendix B: Acronyms/Abbreviations and Definitions……28
Appendix C: Study Briefing to Sponsors (PowerPoint)……29
Appendix D: Selected Bibliography……40

FIGURES

Figure 1: The Greenhouse Effect……..…….....….……..6
Figure 2: 1995-2004 Mean Temperatures…….……..….....…..9
Figure 3: How CC is Linked to Armed Conflict…….…….....…….…..11
Figure 4: The Army's Primary Missions…….…….....…….…..13
Figure 5: Title 10 Functions…….…….....……17
Figure 6: TRADOC Capabilities Development Process……...…….....……..20
Figure 7: USMC K-MAX Operating in Afghanistan…….…….....……..25

TABLES

Table 1: Jan-Dec Global Mean Temperature Over Air & Ocean……...…..…… 7
Table 2: Atmospheric CO_2 at Mauna Loa Observatory……..…..……..…..7
Table 3: Impacts of Temperature Increase in Mean and Variance……..…..…… 8
Table 4: Predictions of CC Conditions……..…..…….....9
Table 5: Humanitarian Mission Expenditures since 1976……..…...……...16
Table 6: Example Technology Areas with Applicability to Future Deployments and Humanitarian Missions……....…..…… 24

1.0 EXECUTIVE SUMMARY

1.1 PRECONDITIONS AND ASSUMPTIONS

In a letter to the Chairman of the Army Science Board (ASB), the Secretary of the Army requested that the ASB conduct a study entitled "Planning for Climate Change." In keeping with the Terms of Reference (TOR) set forth in the SECARMY's request, as well as to preclude a debate on Climate Change (CC), this study assumes that CC is occurring and will get more pronounced over time.

1.2 TOR QUESTIONS

The study team was asked to respond to four questions. In summary, they were:

1. How well can relevant CC conditions by 2030 be predicted?
2. How might CC modify the way the Army fights and accomplishes its Title 10 functions?
3. What does the Army need to consider now to be prepared by 2030?
4. How does Army ensure CC adaptations are appropriate for climate conditions after 2030?

1.3 FINDINGS

The primary finding of this study is that CC will influence the frequency, scale, and complexity of future missions charged to the Army. The study concluded that the Army is not adequately preparing to meet these changes at this time.

In addition, this study team also made subsequent observations based on data gathered during their research:

- Natural variability in weather from today to 2030 will have more impact than CC on how the Army conducts tactical operations.
- CC is likely to increasingly destabilize societal conditions, and that will contribute to the likelihood and severity of conflicts.
- The Army has the ability to mitigate some destabilizing societal conditions and help buffer against exacerbating CC effects.
- The Army's roles of "Prevent" and "Shape" need more development in order to be ready for predicted CC effects.
- Title 10 functions most impacted by CC are Training, Supplying, Equipping, and Organizing.
- Training, equipping, and tasking National Guard and Army Reserve for increased involvement in Stability and Humanitarian Assistance missions has significant merit.
- There does not appear to be a HQDA level coordinating body to establish policy addressing CC for both operating and generating forces.

1.4 PRINCIPAL RECOMMENDATIONS

The research and findings from this study support the following principal recommendations:

1. TRADOC/ ARCIC should identify and codify CC impacts on the Army in the next updates of its doctrinal publications and Capabilities Based Assessments.

2. TRADOC/ARCIC, ICW NGB, and OCAR should improve the effectiveness of humanitarian and stability operations by performing the following actions:

- Design specially tailored forces that are equipped and trained for these operations and that require less effort to deploy and support in the operational area.
- Train functional units for quick responses in order to facilitate and expedite transitions from event occurrence to being Fully Mission Capable (FMC).
- Assign all or a portion of humanitarian and stability missions to the Army National Guard and Army Reserves, taking into consideration the likelihood that Title 32 missions will increase due to CC.

3. ASA(ALT), HQDA G3/G4, TRADOC, AMC should:

- Acquire and field an interim unmanned Vertical Take-off and Landing (VTOL) by FY15 in order to begin developing Tactics Training and Procedures (TTP) for using such a platform for logistics operations.
- Initiate an unmanned VTOL Program of Record with the objective of obtaining the capabilities necessary for the 2030 environment.[1]
- Direct RDECOM to review its S&T portfolios for potential applications to mitigate the effects of CC and report results before FY15.
- Review Acquisition Programs that have not reached Milestone C and determine if CC materially affects system performance requirements.

4. HQDA G3 and TRADOC should determine and implement a program on how units can be trained to work with similar, or representative, entities of government agencies or Non-governmental organizations (NGOs).

5. FORSCOM, ICW NGB, and OCAR should enable and establish annual training events between units and like entities with allied military, other governmental agencies, and NGOs to develop more coordinated and comprehensive approaches to humanitarian and stability operations.

6. Ensure the HQDA level coordinating body:

- Establishes policy to address CC for both the operating and generating forces
- Incorporates climate change considerations into existing Army plans and planning processes (e.g., stationing, disaster response plans, real property master plans, critical infrastructure assessments)
- Monitors the progress and identifies gaps and impacts for periodic reports to Army leadership

7. TRADOC should establish CC as an essential factor in the Concepts to Capabilities Development Process.

[1] See FY2013 Report of Committee on Armed Services, US House of Representatives regarding HR1630.

2.0 INTRODUCTION AND BACKGROUND

The topic of CC and its impact on geography and populations around the world have been in the forefront of government policy, planning, and debate across the globe for well over two decades. A 2013 study published in the journal *Science* evaluated historical connections between climate shift and violent conflict, from "interpersonal violence and crime to intergroup violence and political instability and further to institutional breakdown and the collapse of civilizations."[2] This study, as well as others studies performing similar work, conclude that current CC patterns could "systematically increase the risk of conflict, often substantially"[3] over the next half-century. It should be noted that CC alone has not led directly to conflict. To lead to conflict, CC must work in concert with other social factors such as bad governance, fragility, bad neighbors, or societal inequality. Resilient states and states with minimal inequalities and sound governance seem to be able to mitigate the likelihood of conflict whereas fragile states whose institutions and infrastructure are more tenuous are more susceptible to the effects of CC.

Analyzing the associations between environmental and social factors, researchers claim that the risk of intergroup conflict around much of the planet would be amplified by as much as 50% by 2050.[4] Moreover, studies involving CC and its connection with violence have significantly increased in the last decade. While the studies are recent, it is worth noting that many studies reach as far back as 10,000 BC for information on civilizations all across the world.

Studies in both laboratory settings and of "natural" human situations have found a connection between heat and violence,[5] and higher temperatures have been linked to both innocuous hostile behaviors, such as horn-honking while driving, and more serious behaviors, such as domestic and territorial violence within households and geographic regions.

Conflict is also associated with extreme rainfall, particularly in societies dependent on agriculture. Higher rates of personal violence are found in low-income settings, where agriculture income suffers from extremely wet or dry conditions. New studies reinforce ideas that dramatic climate shifts increase the odds of violent conflict. Shifts in temperature and rainfall directly affect agribusiness, which in turn influences economic productivity and food prices. Subsequent discontent, inequality, and riotous activity stems from inconsistencies in food availability, prices, and the control of each. Moreover, CCs can drive population displacement and urbanization, either of which may lead to clashes over resources.

The implications of the findings from various studies leads researchers to consider new national security challenges that will arise for the Armed Forces if even moderate trends in CC continue.[6] A 2011 Naval Intelligence report on CC states that "military, security, and intelligence analysts are now engaged with the issue, and there's a great deal of thought now being given to the long-term security implications of climate change […] There's very little skepticism within these

[2] Hsiang, Solomon, Marshall Burke, and Edward Miguel. "Quantifying the Influence of Climate on Human Conflict."
[3] Ibid.
[4] Ibid.
[5] Anderson, Craig. "Heat and Violence."
[6] "National Security Implications of Climate Change for U.S. Naval Forces."

circles about the reality of climate change, nor about the potential risk climate change poses to national and international security."[7]

These studies generally suggest that CC will potentially cause problems in infrastructure, resources, wealth, and disease and can alter geopolitical dynamics. In keeping with these findings, the Secretary of the Army has requested this study to specifically address potential impacts on the Army, assuming the predictions of CC and the resulting impacts do become reality, as well as how the Army can and should best prepare for this impact.

2.1 TERMS OF REFERENCE (TOR)[8]

On March 25, 2013, the Secretary of the Army requested the Army Science Board (ASB) conduct a study entitled "Planning for Climate Change." The SECARMY acknowledged that there has been a considerable body of work focused on CC and its implications, with particular attention paid to topics such as changes in geography and resources. In the US, the national security community has also studied the topic of CC and its potential impacts, particularly on how changes in resources might have national security implications in terms of regional and global conflicts in the future.

Operating under the assumptions that the studies are correct, that CC is happening, and that CC will become more pronounced over time, the Army Science Board was asked to consider the following:

- Leveraging to the maximum extent practical the climate data and analyses already available, address how well can relevant climate conditions by 2030 be predicted, i.e., with what level of confidence, associated ranges and granularity

- Assess how expected climate conditions by 2030 might change the way the Army fights, not just tactically but also considering all the Title 10 functions, to include manning, training, and equipping

- Provide recommendations on what the Army needs to consider now to be prepared for the changes that are likely to be manifest by the year 2030

- If yesterday's action has already determined what 2030 will look like, one can say that actions from today onward will determine what 2040 will look like. In that vein, how can the Army ensure that actions it takes in preparation for the world of 2030 are directionally appropriate for CC conditions that are likely to prevail after 2030?

The deliverables of this study include an annotated briefing (Appendix C) and this final written report articulating the findings and recommendations.

[7] Ibid.
[8] Original TOR is included in Appendix A

2.2 BACKGROUND ON CLIMATE CHANGE

There is a plethora of scientific literature on the topic of CC, and with few exceptions, the literature has common findings. Much of the work has been done under the auspices of the United Nations, notably the Intergovernmental Panel on Climate Change (IPCC), which has published a series of reports called "Assessment Reports," the most recent one being Assessment Report 4 (AR4) published in 2007. Of note is that IPCC first published its initial report in 1990, denoting the longevity of this particular study. A new version, AR5, is under preparation but was not yet available in published form for this study. Hence, all references in this document to "the IPCC report" are to IPCC AR4.

In addition to the IPCC, many Federal agencies have collaborated on CC studies, and those agencies have prepared and published ancillary material that focuses on CC within the U.S. The ASB members of the study interviewed representatives of key agencies that have worked on this topic, including the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), and the Department of Energy, to help understand their perspectives and to help focus on the most important aspects of what they have published.

The IPCC and other published reports generally agree that climate trends until 2030 are predictable, whereas climate changes beyond 2030 are much less certain. This is largely because the CC effects that are anticipated by 2030 are mostly determined by greenhouse gases (GHGs) that are already in the atmosphere, which are known. By contrast, CC effects after 2030 are dependent upon emissions scenarios – how much more GHGs are expected to enter the atmosphere. The scenarios range from those predicting modest growth in GHGs to those predicting significant growth, because they depend upon how governments around the world react to global warming. As a general matter, CC effects are expected to worsen as GHG concentrations continue to grow after 2030. These points are captured in a quote from Dr. Thomas Fingar, Deputy Director of National Intelligence for Analysis and Chairman of the National Intelligence Council, who stated: "While the National Intelligence Assessment is based predominately upon a midrange scenario, some of the analysis … refers to IPCC reports with multiple scenarios. However, scientists indicate that even if humans stopped releasing CO_2 tomorrow, climate changes projected for 2030 would still occur."[9]

Before delving into the details of CC, it is important to distinguish the terms "weather" and "climate." Weather is the day-to-day change that occurs in the environment. This is highly specific in terms of location and time, e.g., the temperature in a given city at noon. Climate is a much broader term and is the average of variations of weather in a large area over a long period of time (i.e., decades). Climate can be defined as a trend for a given region of the globe over a period of years. Climate conditions can vary year by year owing to natural factors, such as El Niño patterns and oscillations in the jet stream.

[9] Fingar, Thomas. *National Intelligence Assessment on the National Implications of Global Climate Change to 2030*.

CC will impact weather, and weather is what impacts the Army on a day-to-day basis. Natural variations in the weather tend to obscure the effects of CC, since weather can vary significantly for any given day, yet changes in climate shift gradually.

So how do GHGs affect global temperatures, which then affect CC? The key mechanism is greenhouse warming, where certain gases, most notably carbon dioxide, facilitate the absorption of the sun's radiant energy that is incident on the earth (Fig 1); this solar energy is first absorbed by the surface of the earth and subsequently re-radiated at wavelengths conducive to absorption by greenhouse gases. The absorption can be direct or indirect, the former occurring when the radiant energy strikes the atmosphere, the latter occurring when energy in certain bands (notably infrared) is modulated and reflected towards the earth's surface rather than dissipating into space. The more energy that is retained within the atmosphere, the higher global temperatures will climb. As temperatures increase, the greater the impact on climate conditions (storms, droughts, heat waves at the surface, etc.).

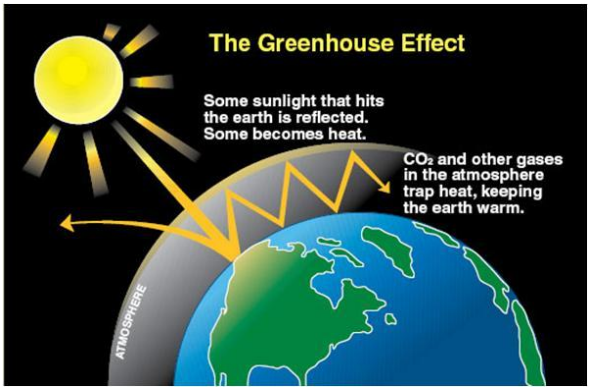


Figure 1: The Greenhouse Effect

The IPCC reports show that global temperatures and GHG content in the atmosphere are both increasing, both factors owing mostly to anthropogenic (human-caused) activities. The reports assert that as discussed above, there is a cause and effect relationship between the two – namely, that GHG increases are prompting temperature increases. Table 1 below illustrates the change in global mean temperature over land and ocean for a period of 130 years, from 1880-2010, The data show: (a) an approximately 1 degree Celsius (roughly 2 degrees Fahrenheit) increase over the past 90 years, and (b) an approximately 0.5 degree Celsius (roughly 1 degree Fahrenheit) increase over the past 30 years. Table 2 shows an increase of approximately 30% in GHGs over the past fifty years since direct measurements began.

Going forward, the IPCC reports predict an approximately 0.7 degree Fahrenheit increase in temperature from today to 2030 due to the GHG already in the atmosphere, an especially relevant point for this particular study. After 2030, the temperature will be affected by new GHG that is put into the atmosphere from today forward. Hence, for purposes of this study, the uncertainties and complexities that attend potential increases after 2030, resulting from the different emissions scenarios, are not evaluated.

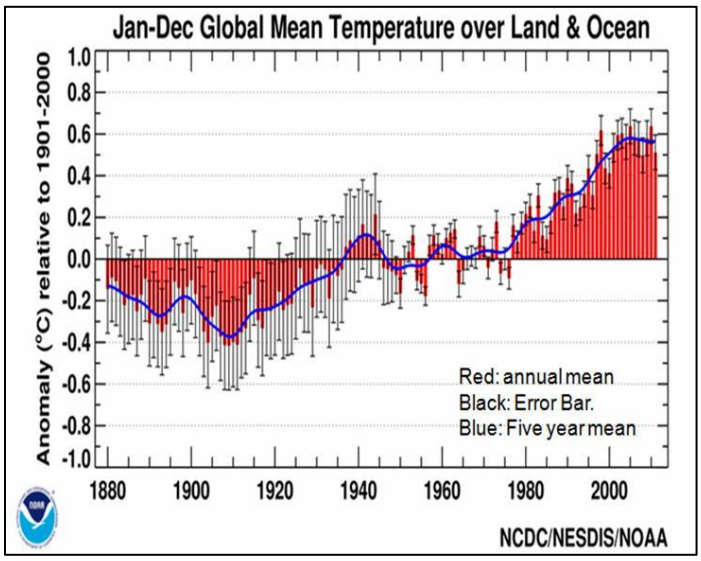


Table 1: Global Mean Temperature over Land & Ocean

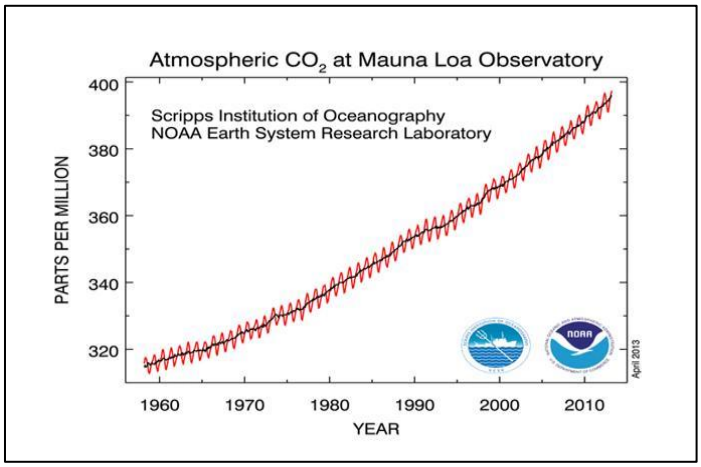


Table 2: Atmospheric CO2 at Mauna Loa Observatory

Even small increases in global average temperature can lead to significant impacts on humans. Significantly hotter weather and extremely hot weather have an adverse impact on human activity and health. Temperature statistics for a given location generally follow a Gaussian (i.e., Normal) probability distribution, and a Gaussian distribution is characterized by a mean and a variance (i.e., standard deviation). Table 3 shows schematically the effects on temperature of both increasing the mean and increasing the variability, both of which have been empirically measured and covered by the IPCC report. This combined shift will multiply the extreme effects of CC by dramatically increasing the probability in the high-temperature "tail" of the distribution. For example, a one degree Fahrenheit increase in the mean and a 0.1 degree Fahrenheit increase in variability can nearly triple the number of extremely hot days.

The IPCC reports note that there are certain low-probability, very high-impact events which if they occurred, would have a significant effect on humans. Two examples are disruption of the oceans' Thermohaline Circulation (which drives the Gulf Stream in the Atlantic Ocean that warms Europe and cools the U.S. East Coast) and the collapse of the Western Antarctic Ice Sheet (which would cause a dramatic rise in ocean sea level). However, the IPCC reports conclude that the likelihood of such events by 2030 is remote; hence, they are not considered further in this report.

The majority of climate conditions vary year by year owing to natural factors unrelated to anthropogenic effects. These natural factors include El Niño/La Niña, volcanic ash, and oscillations in the jet stream. At present and continuing through 2030, the magnitude of natural variability is greater than that from anthropogenic effects, but going beyond 2030, the latter will begin to predominate. Moreover, a key aspect of natural variability is that evaluating the effects of CC must be done based on averaging environmental parameters over a period of years, typically over five years for temperatures and longer for precipitation and other parameters. The ASB assessment has taken this into account.

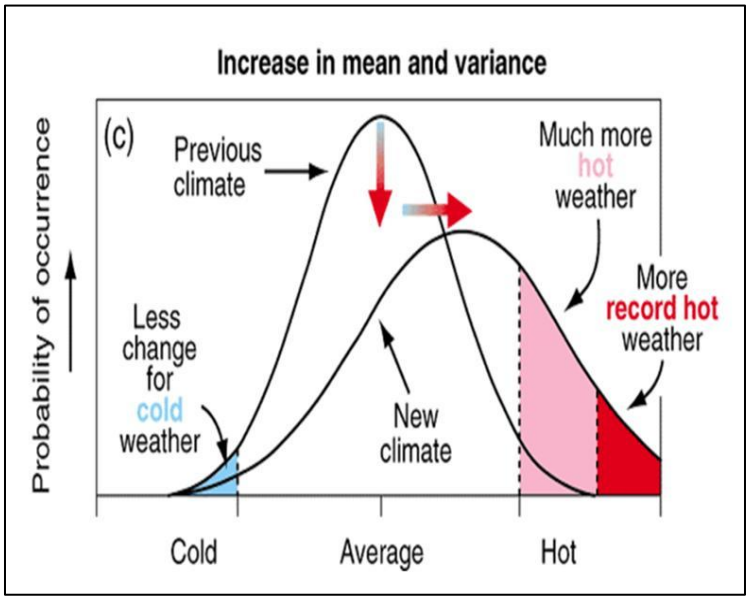


Table 3: Impacts of Termperature Increase on Mean and Variance

How well can CC conditions by 2030 be predicted? The answer varies. Some conditions can be predicted with high confidence; others can't. However, even where specific values cannot be predicted, trends often can be. Complicating matters is the fact that climate parameters vary geographically. They do not change in lockstep around the world. Further, because there are more environmental data in developed areas of the world, the granularity of climate models for those areas can be greater than for other areas of the world, resulting in more detailed analytical results. Figure 2 illustrates the global variability of mean temperatures over a ten-year period.

Table 4 represents a compendium of key environmental parameters which the ASB believes to be the "stressors," meaning those which are most likely to affect the Army. The figure then shows the predicted overall change by 2030 for each stressor, and the direction of the change after 2030. And finally, the figure shows how much confidence the literature contains for each stressor.

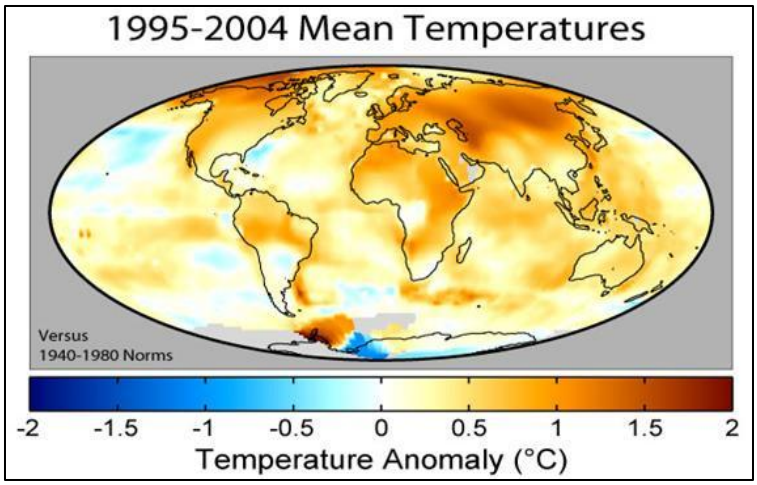


Figure 2: 1995-2004 Mean Temperatures

As the information in Table 4 illustrates, some stressors can be predicted with high or very high confidence; one with moderate confidence; and others with varying degrees of confidence depending upon the region of the world for which the prediction is made.

Environmental Parameter ("Stressors")	Predicted Overall Change by 2030	Impact On People and Environment	Impact on Army Operations
Severity of Tropical Cyclones	Slight Increase	**High**	**High**
Average Precipitation	Wet Areas Get Wetter; Dry Areas Get Drier	**Moderate**	**Moderate**
Heat Wave Events (human morbidity)	Localized Increases	**High**	**Moderate**
Average Surface Temperature	Increase by 0.3 to 0.4 Degrees Centigrade	**Moderate**	**Low**
Frequency of Tropical Cyclones	Slight Decrease	**High**	**Moderate**
Sea Level Rise	Several Centimeters	**Varies (Tidal)**	**Low**
Flood Events	Localized Increases	**High**	**High**
Drought Events	Localized Increases	**Moderate**	**Low**

Source: IPCC AR4, 2007.

Table 4: Predictions of CC Conditions

The appendix to this report contains expanded information on the stressors for five of the U.S. unified combatant commands around the world – EUCOM, AFRICOM, PACOM, CENTCOM and SOUTHCOM. NORTHCOM (Continental U.S., Canada, and Mexico) is not included because the CC effects there are not likely to have a significant impact on deployment of Army expeditionary resources.

To summarize, it is not possible given current data and models to predict climate conditions with the kind of precision that would support the most useful planning. For example, we cannot say that for a specific region of the world, the probability of a Category Three hurricane striking that region is going to increase by a specific percentage between today and 2030. We also cannot say that for a specific region of the world, the likelihood of a devastating flood or drought is going to increase by a specific percentage between today and 2030. We can say that the probability of such events is going to increase – just not by how much. As CC models improve over time, more detailed predictions may become possible, but they are not available today.

From this table, we can deduce that the impact of CC on Army operations varies by factor. However, each of these factors does have its own individual impact. The amount of precipitation in a given time period, for example, will affect agriculture, transportation, and logistics networks, complicating planning and execution factors. Additionally, an increase in severity of tropical cyclones will potentially increase the number of disaster relief missions given to both national and expeditionary forces.

2.2.1 Climate Change and Fragile Countries

Key to understanding CC and its impacts is the concept of *fragility*, which measures a country's overall health using security, economic, political, and social factors. Some characteristics of a fragile state include high poverty rates, marginal food and clean water production and distribution, gender imbalance in schools, and a weak government that leaves vulnerable its population. CC factors are likely to have more influence in fragile states than in resilient states. A fragile state has, at best, marginally adequate institutions to take care of its populace. Fragile states can survive until a disruption (e.g., natural disaster) occurs, and then they become more susceptible to "potentially greater threats" where their "weak infrastructures, internal conflict, and lack of economic development provide fertile ground for trafficking, piracy, terrorism, nuclear proliferation, disease pandemics, regional tensions, and even genocide."[10]

This report finds that CC has a direct impact on a state's fragility. However, increasing fragility can be mitigated through proactive engagement, partnering, and investment in host country infrastructure capacity and resiliency rather than incurring the high costs of responding to future crises, instability, or conflicts. However, it is important to understand that CC effects are not the only factors in establishing a country's fragility. The potential complexities of the relationships between CC and fragile states are represented in Fig. 3.

[10] "Fragile States." *Pulitzer Center on Crisis Reporting.*

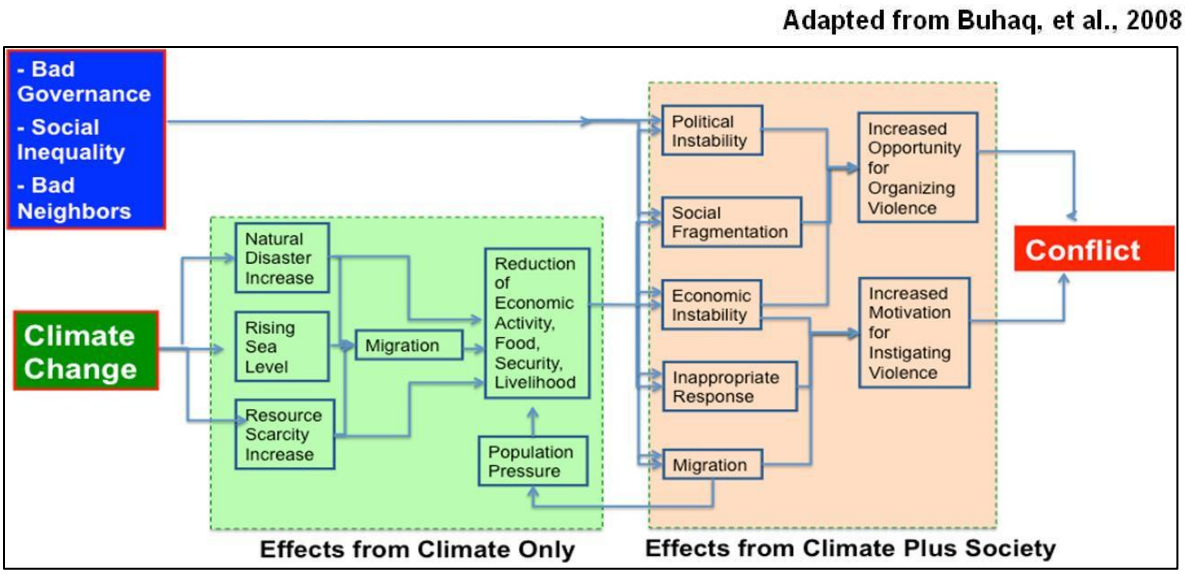


Figure 3: How Climate Change is Linked to Armed Conflict

Figure 3 is a graphical representation of a 2008 study linking CC to armed conflict.[11] Pundits postulated that CC in isolation caused conflict, and hence violent conflict would occur more frequently as climate conditions got worse. Their report states the following:

> "The projected impacts of climate change will not result in elevated conflict risk in all societies. The extent to which these mechanisms play out and increase the likelihood of organized violence depends crucially on country – specific and contextual factors. The resulting causal model depicts a two stage process: whether climate change has adverse socio-political and economic effects on a given society, and second, whether any resulting negative consequences increases the baseline risk of armed conflict. […] Several single case analyses suggest that resource scarcity contribute to outbreak of organized violence, though always in interaction with exogenous conflict-promoting factors."[12]

Thus, while it can be reasonably predicted that increasing CC will have a negative influence on the stability of fragile states and the potential for armed conflict, it is altogether more difficult to predict the time and manner of CC impacts as well as the overall impact such impacts will have.

In sum, states with social factors such as bad governance, fragility, bad neighbors, or societal inequality will be more susceptible to conflict when coupled with CC. Resilient states are more likely to be able to mitigate the potential for conflict, whereas fragile states are particularly susceptible. Therefore, when assessing fragile states, the Army must consider CC as a likely contributor to and, possibly, catalyst for conflict.

[11] Buhaug, Halvard, Nils Petter Gladitsch, and Ole Magnus Theisen. "Implications of Climate Change for Armed Conflict."
[12] Ibid.

2.3 VISITS AND STUDY TEAM APPROACH

The CC research team was made up of the following individuals:

ASB Members
- BG (Ret.) Robert Wynn, USA, Chair
- Mr. Richard Guida, Climate lead
- Dr. Patricia Gruber
- Dr. Endy Daehner
- Dr. Olugbemiga Olatidoye
- Dr. Ivan Somers
- COL (Ret.) William Jerry Tait, USA
- Mr. David Swindle
- Dr. Alan Willner

Government Subject Matter Expert
- Dr. Adam Kalkstein, USMA Faculty

Study Manager
- MAJ Johanna Mora, HQDA G8

Report Editor
- MAJ Erin Hadlock, USMA Faculty

During the course of this study, the team visited or contacted the organizations listed below.

- TRADOC: ARCIC
- HQDA: G2, G3, OCAR, NGB, ASA IE&E
- National Defense University
- RDECOM: ARL, CERL, CERDEC
- LMI
- USMA (Geography/Environmental Engineering)
- NASA: Langley, Goddard
- OSD: Strategic Environmental Research and Development Program
- USACoE: Hydrology/Environment
- SOUTHCOM
- ARSOUTH
- National Oceanographic Atmospheric Administration
- Installation Management Command: Environmental Command

These organizations were selected based on pertinent areas of study as well as presence of subject-matter experts in the fields relevant to CC. In addition to site visits and interviews, the ASB Study Team reviewed authoritative literature on the climate and the Army's Capstone to Capabilities Development Process.[13] The reports of the IPCC represented a foundational resource for this study. Other sources proved helpful when applying CC theories to Army processes. Sources used in this study are identified in the Bibliography provided in Appendix D.

During these site visits, this study identified four specific questions integral in understanding the intersection of CC and Army operations:

[13] Two key documents used in this study were the IPCC Assessment Reports and the National Intelligence Estimates (NIE) 2010.

What does the Army need to do? In answering this question, researchers took into consideration the Army's roles, primary missions that are assigned to it in Defense Guidance, and its Title 10 functions as assigned by the US code.

How is the Army planning to execute their current and future missions as evidenced by their doctrinal publications and materials? The study relied heavily upon TRADOC Pam 525-3-0 (The U.S. Army Capstone Concept), ADP 1, ADP 3-0 and FM 3-07 to look at how the Army currently resources and defines how it will accomplish its roles, primary missions and functions in the near, mid and far term.

How do the effects of CC impact what they plan to do? With the predictable factors identified from current CC research, researchers looked at each factor and how that would affect current and future Army plans. These modifications are represented within this report.

What are the shortfalls/gaps/risks from CC? Finally, the study team specifically looked at the gap between where the Army is and where it should be. Researchers identified those measures the Army will have to take in order to better adapt to the effects of CC.

3.0 FINDINGS AND ANALYSES

3.1 CHANGES TO THE WAY THE ARMY FIGHTS AND ACCOMPLISHES TITLE 10 MISSIONS

Question #2 in the TOR charged the team to answer what impact CC will have on the way the Army fights and accomplishes its Title 10 functions. The study team determined there were actually three parts embedded within that question. In addition to addressing the Title 10 functions, the study opted to interpret the term "fight" both narrowly and broadly, as circumstances warranted. Figure 4 depicts these circumstances and the Primary Missions that are impacted by CC.

Figure 4: The Army's Primary Missions

The narrow view of "fight" is actual armed conflict (i.e., fire and maneuver with supporting functions) as a part of Unified Land Operations. When interpreting fight within this narrow scope, five of the ten primary missions of the Army best fit this definition. Therefore, the team studied how CC would impact these five Primary Missions. In this version, the relevant CC effects are those that affect the Joint Operational Area (JOA), including increases in temperatures, increases dryness and dust, more wetlands, etc.

The second, broader interpretation of "fight" takes into account all ten of the Army's Primary Missions from Defense Guidance. Including these missions means considering the Army's roles of preventing conflict and shaping the environment, in addition to winning the conflict. In doing so, the team found that CC affected two more of the ten Primary Missions. Thus, seven of the ten Primary Missions can be expected to be influenced by CC. The impact of CC on the last three missions appeared to be insignificant.

3.1.1 NARROW FIGHT: HOW THE ARMY FIGHTS

The study team reviewed the Army's Capstone Concept and Operational Concept, considering the most significant effects of CC: more severe storms (tornados, typhoons, hurricanes), increased desertification of semi-arid lands, and increased rain and flooding in wet areas. The condition of nations' infrastructures, particularly in fragile states, will usually suffer from the effects of CC. For example, roads and bridges are more likely to be damaged or in disrepair; communications networks could have portions disrupted; water purification and distribution may not meet the demands of the populace; medical support could be inadequate, lacking skilled staff and supplies; interruptions to the power grid could be widespread. Airports and seaports would also be vulnerable to major disrepair, thereby greatly complicating already tenuous logistics networks.

The challenge with anticipating reactive events is that no situation is the same, and each situation will not be fully realized until it has happened. Each of the points below is either explicitly or implicitly addressed in doctrinal publications. However, the JOA infrastructure may be more inadequate than anticipated, as a result of the impacts of CC. **Accordingly, the study team believes the following items need to be considered more fully:**

1. The availability of adequate sealift and airlift to deploy and support the expeditionary force warrants lightening the footprint and increased pre-positioning or staging equipment.
2. Ground maneuver and logistics will often be impacted by the resultant reduced road infrastructure and potentially increased use of IEDs. This situation limits or slows cross-country movement. VTOL capability can compensate for these effects.
3. Population growth and migration will increase unrest in the urban areas. Current literature views the urban environment as less of an advantage for the US Army.
4. Unmanned VTOL, in initial modeling and USMC experience, provided a more efficient and effective means of supplying distributed forces than ground convoy.
5. Units and individual Soldiers within the JOA must be lightened. Less consumption and less waste production are needed. Recycle of water, renewable energy, high specific capacity energy sources, and repurpose of material are key.

6. Basing supporting assets outside the JOA and bringing their effects forward when needed reduces exposure and reduces the logistics demand associated with these forces within the JOA.

Additionally, this study concluded that CC effects will also challenge equipment capabilities. Although CC is not expected to create significant increases in average temperatures through 2030, it is likely to create significant increases in the number of 'hot' days and other adverse weather as discussed earlier in this report. Thus, equipment designed to operate under adverse environmental conditions is likely to experience an increase in the duration of such conditions. This means that existing equipment should be evaluated to establish whether that increase may shorten design lifetime or inhibit equipment performance. Further, new equipment should be designed on the expectation that future environmental conditions will be worse than what they are today, as documented in this study and its references.

For example, during operations in Iraq and Afghanistan, many items of ruggedized commercial equipment were rapidly acquired to meet operational needs. Many of these items performed well. Others, primarily because of heat, dust, sand storms, or inadequate support and training were removed from the units and stored. CC's effects will make the environment more challenging for this type of equipment's capabilities and resiliency.

3.1.2 BROAD FIGHT: OTHER PRIMARY MISSIONS

Due to its effects on all societies, CC will present the Army with more frequent and complex opportunities to support humanitarian and stability operations, missions that the US has conducted for decades. Stability operations (i.e., Security Force Assistance) are typically enduring engagements, potentially lasting several years. The goals of stability operations are to strengthen friendly governments and to reduce the likelihood of conflict through training in tactics, logistics and equipping, staff procedures, border security, and support for improved governance. Humanitarian missions, on the other hand, typically involve a rapid response to a disaster with the mission of providing relief to a population in the form of rescue, recovery, or restoration, for example. Humanitarian missions support recipient governments until such time as they are able to fully support their own recovery, the goal of which is months rather than years. The Army has routinely called upon its most ready combat units to respond to Humanitarian operations. The increased frequency and scope of these deployments will distract them from training for their Mission Essential Task List (METL) and dissipate the readiness condition of the unit. Expanding missions will challenge Army combat units in retaining wartime expertise.

This study recognizes the need to address both of these primary missions—stability and humanitarian operations—as CC will have particular impacts on both. Thus, the Army's roles of "Prevent" and "Shape" require increased emphasis, education, training, and involvement to reduce the likelihood of conflict, particularly in fragile states which may request the Army's assistance.

The likelihood of the Army being engaged in humanitarian operations increases because of the increased severity of tropical cyclonic storms. The figure in Table 5 shows the amount

of money expended for humanitarian missions outside the US since 1976. The data indicates an increase in the frequency and cost of humanitarian missions over the past decade. It should be emphasized that the decision for the US to engage in a humanitarian mission rests with the President. Responding to a request for assistance and sending US troops to a foreign country to assist is a Commander-in-Chief level decision. Therefore, this report does not assume automatic participation in all disaster and humanitarian events but rather that CC will present the President with more decision points and will potentially complicate those decision points. Moreover, the US involvement and decision process will be constrained by many factors, including the Department of Defense budget, downsizing of the armed forces, geopolitical realities, and the commitment of the US population. Military forces must also consider humanitarian missions in CONUS and OCONUS differently. While expeditionary forces will more than likely not be used in CONUS operations, National Guard units in affected states may need augmented support from active duty forces.

Source: Margesson, CRS Report for Congress, 2006

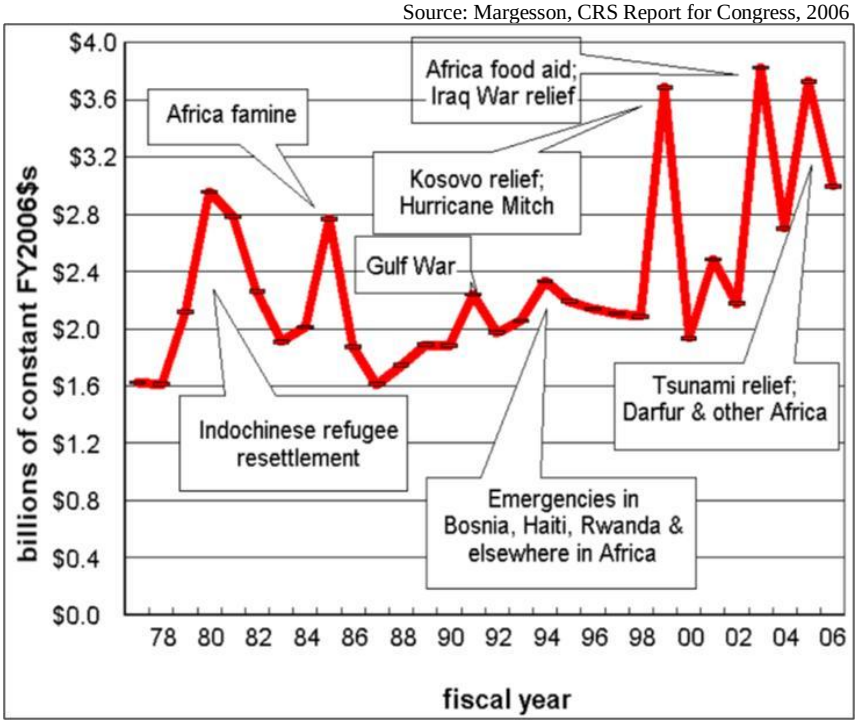


Table 5: Humanitarian Mission Expenditures since 1976

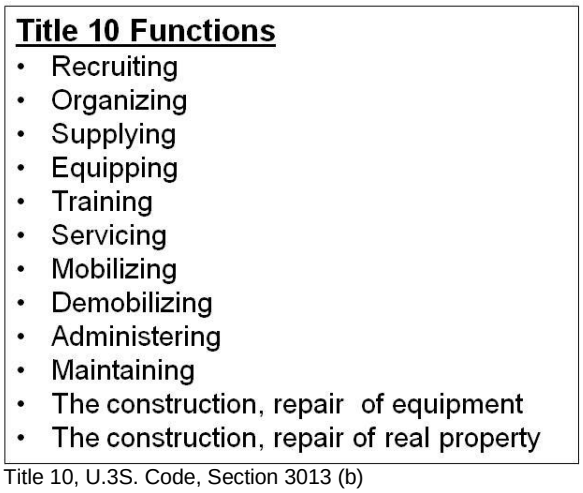
Regardless of the ancillary and unpredictable issues surrounding disaster relief, the Army must be prepared for the growth in frequency, scale, and complexity of humanitarian missions. The effects of CC will "raise the mission bar" for the Army in terms of expected increases in humanitarian assistance.

3.1.3 TITLE 10 FUNCTIONS

Of the Title 10 functions (Fig. 5), this study determined that four of the twelve functions will be notably impacted by CC: supplying, equipping, training, and organizing.

Training: The study team assessed the tasks contained within the Title 10 functions against the effects of CC for both the installations and the deploying force. Training will be affected most significantly by CC in several ways. First, available training time may need to be altered based on increasingly more hot weather conditions. Units may need to train early in the morning or shorten training altogether. Additionally, the type of training units perform will change as the roles of disaster relief and humanitarian aid expand. Recommendations to how units should integrate this training are discussed in Section 4.2. Finally, units will need to increase weather and/or meteorological awareness into training.

This last point is especially relevant, as increases in both the severity and frequency of heat waves have the potential to negatively impact soldiers' health in the future. Heat is already the leading weather-related killer in the United States, and the potential exists for CC to further compound this problem.[14,15] In fact, each year numerous soldiers suffer from heat-related illness, and it is likely these numbers will rise in the future.



Title 10, U.3S. Code, Section 3013 (b)

Figure 5: Title 10 Functions

The Army currently relies on a Heat Category System (HCS) to warn soldiers of potentially dangerous heat conditions. Based on the Wet Bulb Globe Temperature (WBGT) developed in the late 1950's for the Marines, the HCS categorizes current meteorological conditions into a one through five scale to convey the potential danger to soldiers. Not surprisingly, heat-health research has progressed significantly over the past 50 years, and the HCS omits numerous variables shown to impact human health such as minimum temperature, time of year, and consecutive days of a heat wave.[16,17] Further, the HCS is an *absolute* system that assumes people in all locales respond similarly to the heat. Current heat-health research highlights that the impacts of heat are *relative*, and people respond very differently to heat depending on location.[18] In addition, research conducted on soldiers confirms that acclimatization to environmental

[14] Gosling, S, G. McGregor, and J. Lowe. "Climate Change and heat-related mortality in six cities."
[15] Peng, R, J. Bobb, C. Tebaldi, L. McDaniel, M. Bell, and F. Dominici. "Toward a Quantitative Estimate of Future Heat Wave Mortality Under Global Climate Change."
[16] Anderson, G. and M. Bell. "Heat Waves in the US: Mortality Risk During Heat Waves and Effect Modification by Heat Wave Characteristics in 43 US Communities."
[17] Basu, R. "High Ambient Temperature and Mortality."
[18] Sheridan, S, A. Kalkstein, and L. Kalkstein. "Trends in Heat-related Mortality in the US, 1975-2004."

conditions occurs quickly, further highlighting that a relative system would be advantageous to an absolute system, despite the transient nature of the military.[19]

It is important to note that the majority of locations using the HCS will experience numerous Category 5 days (the most severe) throughout the summer. As a result, it is difficult to differentiate between a "typical" Category 5 day and a day that is truly exceptional and highly dangerous. In addition, the large number of Heat Category 5 days results in reduced soldier productivity due to mandatory work restrictions, and the impact of CC on heat will only serve to exacerbate this problem.

There are significantly better means to provide modern heat-health warning technology. As one of several examples, the Heat Stress Index (HSI) is a relative system that takes into account numerous meteorological variables known to impact human health, many of which are omitted by the HCS.[20] Based upon the conditions present, the HSI produces a daily value from 0 through 100, with a 99 representing a day with conditions in the worst 1% of days for a given time of year at a given locale. The HSI is simple and easy-to-understand, and research suggests that it is highly effective at determining the risk to human health.

Supplying: Techniques for supplying deployed troops in potentially anti-access/area denial environments that have debilitated infrastructures need to be developed, tested, and eventually adopted. For installations, contingency plans for disruptions need to be current and resourced.

Organizing and Equipping: The mission modifications caused by the effects of CC and the regional orientation will very likely result in modifications to units' organization and equipment. If units, or parts of units, were to be tailored to respond to humanitarian operations, their equipment would be lighter, requiring less lift; their structure and composition would be modified. Increased emphasis in new equipment design should include reduced size, weight, and power (needs) as well as increased time between scheduled maintenance.

4.0 SUMMARY of FINDINGS AND RECOMMENDATIONS

4.1 SUMMARY of FINDINGS

In its capstone documents, the Army recognizes the challenges inherent in conducting Unified Land Operations. However, the exacerbating effects of CC make mission accomplishment more challenging. This is particularly true in fragile states where the transportation, water, power and communications infrastructure are marginally adequate to begin with. These fragile states are the most likely areas to which the Army will be deployed.

To maintain a decisive advantage in conducting Unified Land Operations, the Army needs to place more emphasis now to mitigate CC effects on the ability of combat units to maneuver on the ground and to be reliably supported by the road network.

[19] Radakovic, S., J. Maric, M. Surbatovic, S. Radjen, E. Stefanova, N. Stankovic, and N. Filipovic. "Effects of Acclimation on Cognitive Performance in Soldiers During Exertional Heat Stress."
[20] Watts, J. and L. Kalkstein. "The Development of a Warm-Weather Relative Stress Index for Environmental Applications."

The Army, possessing a well trained, equipped and ready force, certainly deters enemies and encourages friends. However, the Army needs to examine its role of "Prevent" more completely and document more actions it can take in order to reduce the likelihood of conflict. "Shaping" the environment through Security Force Assistance will continue to expand as a mission for the Army in the operational environment. New tasks, challenges and opportunities will likely emerge. The Army needs to find means to accomplish these emerging missions by first recognizing and expanding their missions and then by preparing for them. It must be more effective and efficient in austere, fragile states, with the objectives of enhancing the national security environment while not eroding its own warfighting capability.

The effects of CC will impact the Title 10 functions of Training and Supplying both in the generating force (installation) and in the operating force. As previously stated, both availability of training time and methods of training must be considered here. Training time will certainly be curbed by higher temperatures occurring with greater frequency and variability, affecting generating and operating units. In fact, Heat Category 5 (although we argue against this out-of-date category system in this paper) forces units to curtail or adapt training even now, usually to the detriment of the training. Additionally, more unit level training with other Government Agencies and Non-Governmental Organizations (NGOs) is needed to enhance on-the-ground operations.

To a certain extent, the Army already takes weather manifestations into consideration in preparation for any mission planning. Tactical leaders regularly consider mission, enemy, terrain and weather, troops and support available, time available, and civil considerations (METT-TC) for front, deep, and rear echelons of training and warfighting operations. These six mission variables narrow the focus for the tactical leader, enabling him to achieve mission success. This study contends that CC and its complexities can be accommodated within existing processes, given appropriate guidance and focus. Analogous constructs including CC and weather extremes will fit readily into the much longer planning cycles appropriate to readiness, force design, unit tailoring, training, and equipping in order to meet demands of the future force.

Installations need to determine now what operations and facilities are critical to mission accomplishment. Potential supply disruptions which jeopardize operations will have to be backed up with independent, alternative means. Supplying deployed units in all missions will be more difficult due to the significant potential of reduced local availability of support and the reduced transportation network in the JOA. Demand from deployed units needs to be reduced via recycle, recharge, repair, and repurpose activities.

Organizing and Equipping units to meet new and tailored tasks brought about by CC will occur more frequently and disrupt routine activities. Units will have a significant challenge in not only preparing for these new, tailored tasks but in equipping them as well. TRADOC/ARCIC has instituted a thorough planning process to prepare the Army for the future operational environment. However, the highest risks in this system are fiscal constraints and the time elapsed from when a material solution is identified until it is actually in units and being used.

4.2 PRINCIPAL RECOMMENDATIONS

4.2.1 "TRADOC/ ARCIC: identify and codify the CC impacts on the Army in the next updates of its doctrinal publications and its Capabilities Based Assessments."

More specific, probable effects of CC on the operating environment, particularly upon fragile states, need to be identified and documented by TRADOC/ARCIC. The CC effects on Army units deploying or executing primary missions also need to be initially documented and kept current as considerations in the Operating Concepts and other doctrinal publications. Finally, the effects of CC need to be codified into the Capabilities Developments Process, as shown in Figure 6.

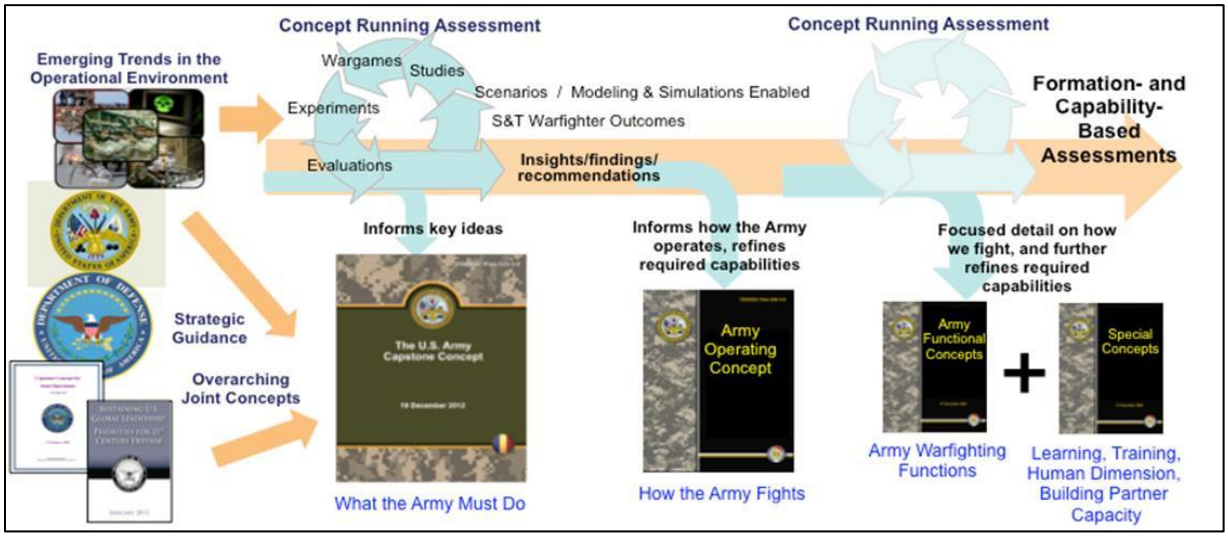


Figure 6: TRADOC Capabilities Development Process

4.2.2 "TRADOC/ ARCIC, ICW NGB, and OCAR: improve effectiveness of humanitarian and stability operations by:

- **Designing specially tailored forces equipped and trained for these operations whose lift requirements and footprint are reduced.**
- **Training specially trained functional unit "plugs" for quick response.**
- **Assigning all or a portion of the missions to the Army National Guard and Army Reserves, with consideration of increased Title 32 missions due to CC."**

TRADOC/ARCIC, in coordination with the National Guard Bureau and the Office of the Chief of Army Reserve, needs to embark on a study to improve the capabilities and effectiveness of humanitarian and stability operations by designing specially tailored forces equipped and trained for these operations. The lift requirements and support requirements (e.g., using an acceptable

amount of appropriately ruggedized COTS equipment) need to be reduced to improve the timeliness of their arrival on the ground. These re-tailored units, specifically designed, equipped, trained, and designated to support Humanitarian operations offer several benefits. Among these, they would allay the demand on the Army's most ready combat units. The new units could have modularly designed detachments with unique skills and equipment that would deploy based upon mission needs. If the units were in the National Guard, they could support both state and federal requirements. The continuity of manning in the National Guard would provide the Soldiers more opportunity to improve their skills for this type of mission. Consideration of the increased demand on the Title 32 functions for the Army National Guard would be necessary for this study.

4.2.3 "ASA(ALT), HQDA G3/G4, TRADOC, AMC:

- **Acquire and field an interim unmanned VTOL program for evaluation by FY15**
- **Initiate an unmanned VTOL Program of Record with the objective of obtaining the capabilities necessary for the 2030 environment. (See FY2013 Report of Committee on Armed Services, US House of Representatives regarding HR1630)**
- **Direct RDECOM to review its S&T portfolios for potential applications to mitigate the effects of climate change and report results before FY15**
- **Review Acquisition Programs that have not reached Milestone C and determine if CC materially affects system performance requirements."**

As the study team examined the CC effects on how the Army fights, it became apparent that freedom of maneuver on the ground could become increasingly risky. Poor roads, weak bridges, possibly increased desertification or increased inundated terrain made ground maneuver and movement problematic. Ground transport for resupply to units would be risky and minimally responsive as well. A debilitated transportation network, increased likelihood of Improvised Explosive Devices (IEDs), sniper fire or ambush each contribute to significantly increasing the operational costs of resupply.

Manned VTOL has proven its effectiveness and efficiency in past operations for maneuver, resupply and evacuation. Unmanned VTOL has operated commercially for years. The USMC showed the benefits of unmanned resupply in Afghanistan. Future improvements in both efficiency and effectiveness of unmanned VTOL seem realizable once the Army actually trains with them and develops relevant Tactics, Techniques and Procedures (TTPs). Even so, the performance of the current inventory of VTOL has lagged. The Army needs to invest in improving lift capacity, resilience, and operating range of its VTOL fleet by upgrades or a new program of record.

The Army must not be caught unaware; investment is needed now. The S&T community needs to address the effects of CC and how to mitigate them in Army operations, and PORs need to do an assessment to ensure CC effects are addressed in their respective programs.

4.2.4 "HQDA G3 and TRADOC: determine and implement a program on how units can be trained to work with similar, or representative, entities of government agencies or NGOs."

Units executing humanitarian, disaster relief and stability operations frequently are called upon to work closely with other organizational entities. These could be from the Federal Government (e.g., USAID), allied military, or NGOs (e.g., International Red Cross). Army headquarters are already conducting meetings and staff exercises with these agencies and NGOs in order to better coordinate actual operations. This must continue to lower echelons, too, where we anticipate the most frequent contact. Lack of training in working with these type of entities introduces inefficiencies and, at times, conflicting activities.

Unfortunately, most of these organizations' personnel have worked in the same capacity for a number of years and are experienced, requiring little periodic training. Military units, on the other hand, will be far more efficient from day one, if they receive periodic training. HQDA G3 and TRADOC need to determine and implement a program on how units can be trained to work with similar or representative entities of government agencies or NGOs.

4.2.5 "FORSCOM, ICW NGB, and OCAR: enable and establish annual training events, between units and like entities with allied military, other governmental agencies and NGOs to develop more coordinated and comprehensive approaches to humanitarian and stability operations."

FORSCOM ICW the NGB and OCAR should enable and establish annual training events between units likely to be called upon for these missions with the objective of developing more comprehensive and coordinated approaches to these missions.

4.2.6 "Ensure the HQDA level coordinating body:

- **Establishes policy to address CC for both the operating and generating forces**
- **Incorporates climate change considerations into existing Army plans and planning processes (e.g., stationing, disaster response plans, real property master plans, critical infrastructure assessments)**
- **Monitors the progress and identifies gaps and impacts for periodic reports to Army leadership."**

The recommendations in this section directly address TOR Question #4: "How does the Army ensure CC adaptations are appropriate for climate conditions after 2030?"

In order to do this, this study submits that the HQDA level coordinating body should establish policy to address CC for both the operating and generating forces. Further, the body should ensure CC considerations are incorporated into existing Army plans and planning processes (e.g., stationing, disaster response plans, real property master plans, critical infrastructure assessments); and monitors the progress and identifies gaps and impacts for periodic reports to Army leadership. Finally, TRADOC should establish CC as an essential factor in its robust Concepts to Capabilities Development Process.

4.2.7 TRADOC should establish CC as an essential factor in the Concepts to Capabilities Development Process.

4.3 WAY FORWARD FROM SCIENCE AND TECHNOLOGY

ASA(ALT), AMC: Direct RDECOM to review its S&T portfolios for potential applications to mitigate the effects of CC and report results before FY15.

Table 6 lists Science and Technology (S&T) areas that were recommended in a previous ASB study[21] to increase efficiency and effectiveness of expeditionary forces. These same S&T areas are applicable to humanitarian missions as well and will help mitigate some of the effects that CC may induce on deployed forces on either humanitarian or warfighting missions. Examples are as follows:

- Portable water purification systems can be distributed over several locations to ease the impacts of a lack of mobility from either natural disasters or wartime conditions, thereby supplanting a central source.
- Aerial weather sensors can be placed on airborne platforms such as helicopters and UAVs to allow for better forecasting of local weather.
- Modular moveable rigid-walled shelters would provide deploying forces with rapidly-constructed protection for COPs or PBs, allowing the Army to devote more Soldiers to mission roles more quickly. These same shelters can provide temporary housing for those affected in humanitarian missions.
- Renewable power sources obviate the need for as much fuel to be transported for either the warfighting or humanitarian missions. The savings in weight and delivery in-country can be significant (as many studies have concluded). The need for resupply of fuels is reduced, as well.
- Turbine engines which currently use 1970s technology may need modifications or upgrades to allow for better resiliency and reliability for mission operations under more challenging weather conditions induced by CC. The ratio of flight time to maintenance time restricts the utility of these platforms.
- Unmanned VTOL Systems will allow more supplies to be flown to remote areas with less risk to pilots. VTOL is discussed more fully in the next section.

[21] Army Science Board. *Strengthening the Sustainability and Resiliency of a Future Force.*

Science and Technology Area	Expeditionary Application	Humanitarian Application
Portable Water Purification Systems	Ensure Water Supply in AO	Distributed Water if Local Supply Unusable
Aerial Weather Sensors	Better Weather Predictions	Better Weather Predictions
Improved Vision Sensors	Operations at Night and in Dust Storms	Allow All-Weather Support Operations
Advanced Battery Power	Reduced Deployment Weight	Reduced Deployment Weight
NextGen Power Systems	Power Efficiencies at FOBs, COPs and PBs	Emergency Power
Renewable Power Sources • Wind • Solar PV	Reduced Reliance on Fuel-Driven Systems	Reduced Reliance on Fuel-Driven Systems
Modular Shelter Systems	Reduced time to Build COP, PB Housing	Temporary Housing
Unmanned Systems • Ground • Air	Reduce Vulnerability; Improve Security and Situational Awareness	Establish Central Communications Links
Unmanned VTOL Systems	Reduced Risk in Resupply Missions	Supplies to Remote Areas
Turbine Engines	Improved Helicopter Engine Resilience	Improved Helicopter Engine Resilience

Table 6: Example Technology Areas with Applicability to Future Deployments and Humanitarian Missions

4.3.1 Unmanned VTOL Support

This study team sees modernized VTOL, both manned and unmanned, as an essential asset to the Army as they perform increasingly frequent and complex missions caused by CC. Furthermore, in May 2013, the House Armed Services Committee (HASC) urged the Army to boost its efforts toward adding a cargo UAS program. Lawmakers have recently charged the Army to estimate the cost to buy, operate, and sustain a cargo UAS program similar to K-MAX (Fig. 7). The panel also wants details on how a cargo UAS program would fit into the Army's larger logistical structure. The lawmakers wrote into their mark-up of the 2014 defense budget, "The committee is concerned that the Army, despite having very similar logistical challenges [as the US Marine Corps], does not have a cargo UAS program. Therefore, the committee directs the Secretary of the Army to submit a report to the congressional defense committees, by February 15, 2014, assessing the potential utility of an Army cargo UAS."[22] Unmanned VTOL has performed

[22] House Report 113-102

favorably for the USMC in Afghanistan, and the 2010 ASB study, "Strengthening Sustainability and Resiliency of a Future Force," determined that the improved effectiveness (less Soldier exposure) and efficiency (less operational costs) of manned VTOL was superior to using ground vehicles in support operations.[23] This study team sees VTOL as a viable asset to the Army as they perform increasingly frequent and complex missions caused by CC.

Figure 7: USMC K-MAX Operating in Afghanistan

[23] This study employed the OPLOG Planner and Sustain the Mission Project Decision Support Tool.

5.0 APPENDICES
Appendix A: TERMS OF REFERENCE (TOR)

SECRETARY OF THE ARMY
WASHINGTON

MAR 2 5 2013

Mr. George Singley
Chairman, Army Science Board
101 Army Pentagon
Washington, DC 20310

Dear Mr. Singley:

I request that the Army Science Board (ASB) conduct a study entitled "Planning for Climate Change." The study should be guided by, but not necessarily limited by, the Terms of Reference (TOR) described below.

There has been a considerable body of work focused on climate change and its implications, with particular attention paid to topics such as changes in geography and resources. The national security community has also studied this topic, particularly how changes in resources might have national security implications in terms of regional and global conflicts of the future. These studies, generally, suggest that climate change potentially will cause problems in infrastructure, resources, etc. and change the geopolitical dynamic.

Assuming the studies are correct and that climate change is happening and will become more pronounced over time, the Army Science Board is asked to consider the following:

- Leveraging to the maximum extent practical the climate data and analyses already available, address how well can relevant climate conditions by 2030 be predicted, i.e., with what level of confidence, associated ranges and granularity.
- Assess how expected climate conditions by 2030 might change the way the Army fights, not just tactically but also considering all the Title 10 functions, to include manning, training and equipping.
- Provide recommendations on what the Army needs to consider now to be prepared for the changes that are likely to be manifest by the year 2030.
- If yesterday's action has already determined what 2030 will look like, one can say that actions from today onward will determine what 2040 will look like. In that vein, how can the Army ensure that actions it takes in preparation for the world of 2030, are directionally appropriate for climate change conditions that are likely to prevail after 2030?

I am the sponsor of this study, which is expected to conclude in 2013. The ASB must present a comprehensive briefing to me by September 30, 2013. The final written report must be provided by October 31, 2013.

The study will operate in accordance with the Federal Advisory Committee Act, and Department of Defense (DoD) Directive 5105.4, the "DoD Federal Advisory Committee Management program." It is not anticipated that this study will need to go into any "particular matters" within the meaning of Title 18 United States Code Section 208, nor will it cause any member to be placed in the position of acting as a procurement official.

Sincerely,

John M. McHugh

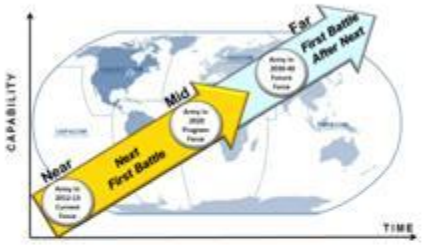
APPENDIX B: ACRONYMS AND DEFINITIONS

ASB	Army Science Board
ASA(ALT)	Assistant Secretary of the Army for Acquisition, Logistics, and Technology
AR4	Assessment Report 4
AR5	Assessment Report 5
ARCIC	Army Capabilities Integration Center
AFRICOM	Africa Command
ASA IE&E	Assistant Secretary of the Army for Installations, Energy, and Environment
ARL	Army Research Laboratory
ARSOUTH	Army South
AMC	Air Mission Command
CC	Climate Change
CBA	Capabilities Based Assessment
CENTCOM	Central Command
COTS	Commercial, Off The Shelf
COP	Combat Outpost
CONUS	Continental United States
CERL	Construction Engineering Research Laboratory
CERDEC	Communications-Electronics Research, Development and Engineering Center
DOE	Department of Energy
EUCOM	European Command
FMC	Fully Mission Capable
FORSCOM	Forces Command
GHG	Greenhouse Gases
HASC	House Armed Services Committee
HCS	Heat Category System
HQDA	Headquarters, Department of the Army
HSI	Heat Stress Index
ICW	In conjunction with
IPCC	Inter-governmental Panel on Climate Change
IED	Improvised Explosive Device
JOA	Joint Operations Area
LOS	Line of Sight
METL	Mission Essential Task List
METT-TC	Mission, Enemy, Terrain and Weather, Troops and Support Available, Time Available, and Civil Considerations
NGB	National Guard Bureau
NGO	Non-governmental Organization
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NORTHCOM	Northern Command
NIE	National Intelligence Estimates
OCAR	Office of the Chief, Army Reserve
OSD	Office of the Secretary of Defense
OCONUS	Outside of Continental United States
PACOM	Pacific Command
POR	Program of Record
PB	Patrol Base
RDECOM	Research, Development, and Engineering Command
SECARMY	Secretary of the Army
S&T	Science and Technology
SOUTHCOM	Southern Command
TOR	Terms of Reference
TRADOC	Training and Doctrine Command
TTPs	Tactics, techniques, and procedures
USMC	United States Marine Corps
USACOE	US Army Corps of Engineers
USMA	United States Military Academy
USAID	US Agency for International Development
UAS	Unmanned Aerial Systems
VTOL	Vertical Take-off and Landing
WBGT	Wet Bulb Globe Temperature

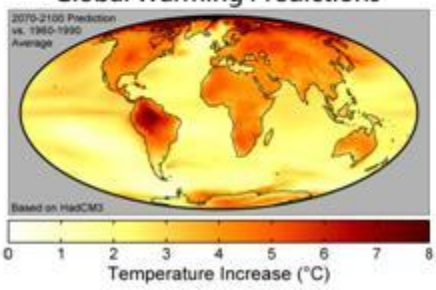
APPENDIX C: BRIEFING CHARTS

Planning for Climate Change

Actions for the Army to Better Adapt to Effects of Climate Change (CC) circa 2030



Global Warming Predictions



July 17, 2013

Bob Wynn, Chair

Draft Version 8A
7-17-13

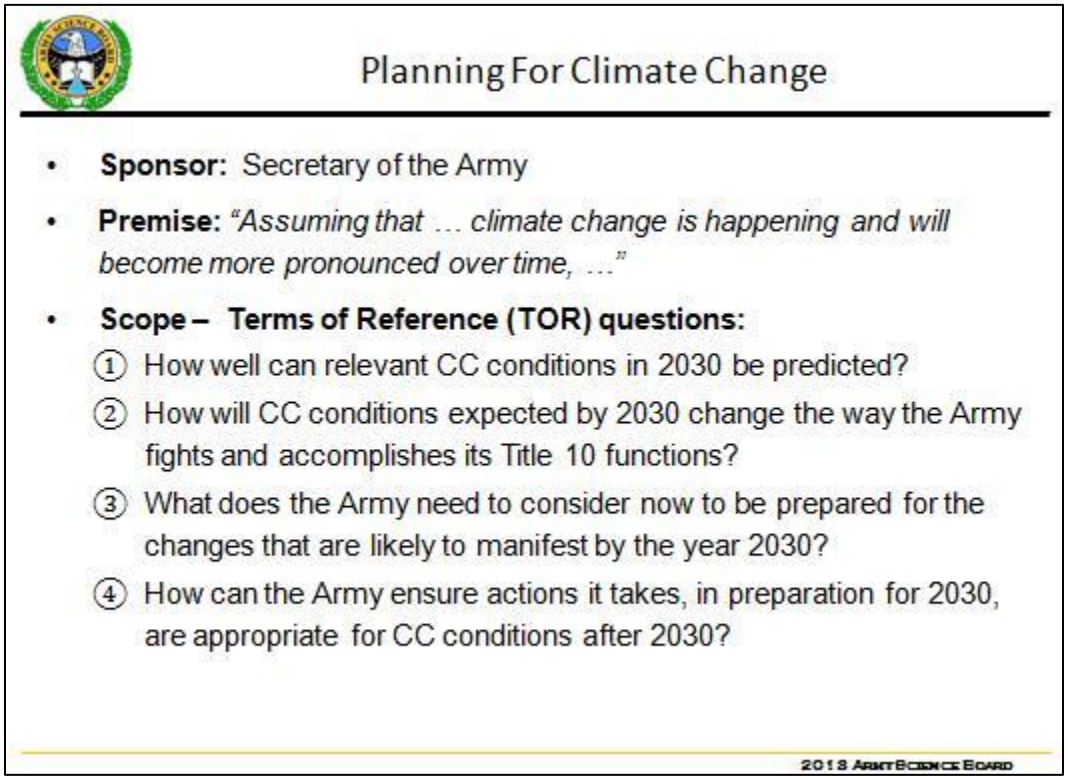
2013 ARMY SCIENCE BOARD

Briefing Outline

- Terms Of Reference (TOR)
- Organization & Information Sources
- Climate Change (CC) Background
- Relevant CC Predictions
- CC effects on the Army
  - *Roles, Missions, Functions*
- Summary Findings
- Recommendations

Tomorrow's environment requires an agile Army that will continue to adapt

2013 ARMY SCIENCE BOARD


Planning For Climate Change
• Sponsor: Secretary of the Army
• Premise: "Assuming that … climate change is happening and will become more pronounced over time, …"
• Scope – Terms of Reference (TOR) questions:
① How well can relevant CC conditions in 2030 be predicted?
② How will CC conditions expected by 2030 change the way the Army fights and accomplishes its Title 10 functions?
③ What does the Army need to consider now to be prepared for the changes that are likely to manifest by the year 2030?
④ How can the Army ensure actions it takes, in preparation for 2030, are appropriate for CC conditions after 2030?
2013 Army Science Board


Organization and Information Sources
• ASB Members
• BG Robert Wynn USA (Ret), Chair
• Mr. Richard Guida, Climate Lead
• Dr. Patricia Gruber
• Dr. Endy Daehner
• Dr. Olugbemiga Olatidoye
• Dr. Ivan Somers
• COL William Jerry Tait USA (ret)
• Mr. David Swindle
• Dr. Alan Willner
• Government Subject Matter Expert
• Dr. Adam Kalkstein, USMA Faculty
• Study Manager
• Major Johanna Mora, HQDA G8
• Report Editor
• Major Erin Hadlock, USMA Faculty
• Literature Review
• United Nations Intergovernmental Panel on Climate Change (IPCC*) Assessment Reports (AR)
• National Intelligence Estimates (NIE) 2010
• See report bibliography
• Primary Source Interviews/Site Visits
• TRADOC: ARCIC
• HQDA: G2, G3, OCAR, NGB, ASA IE&E
• NDU
• RDECOM: ARL, CERL, CERDEC
• LMI
• USMA (Geography/Environmental Engineering)
• NASA: Langley, Goddard
• OSD: SERDP
• USACoE: Hydrology/Environment
• SOUTHCOM
• ARSOUTH
• NOAA
• IMCOM: Environmental Command
* IPCC: scientific intergovernmental body, set up at the request of member governments. First AR was published in 1990
2013 Army Science Board

Bottom Line Up Front

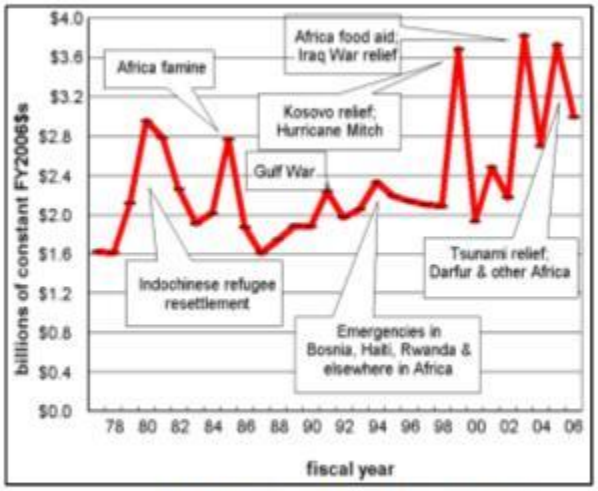
Army is not adequately Preparing to Meet the Changing Nature of Future Missions Caused by CC

- Weather variability from today to 2030 will have more impact than CC on how the Army conducts tactical operations
- CC will increasingly destabilize societal conditions that contribute to conflicts
- Army has the ability to mitigate destabilizing societal conditions and help buffer against exacerbating CC effects
- Roles of "Prevent" and "Shape" need more development to better deal with oncoming CC effects
- Title 10 functions most impacted by CC are: Training, Supplying, Equipping, and Organizing
- Training, equipping, and tasking National Guard and Army Reserve for increased involvement in Stability and Humanitarian Assistance missions has significant merit

2013 Army Science Board

CC Raises the Mission Bar for the Army

- US has conducted stability and humanitarian operations for decades
- As the scope and frequency of stability/humanitarian ops increase due to CC, demand for Army engagement will increase
- However, Presidential decisions determine whether the Army will support these operations.
- Involvement constrained by:
  - Defense budget, downsizing of armed forces, geopolitics, will of the US population, etc.



Source: Margesson, CRS Report for Congress, 2006

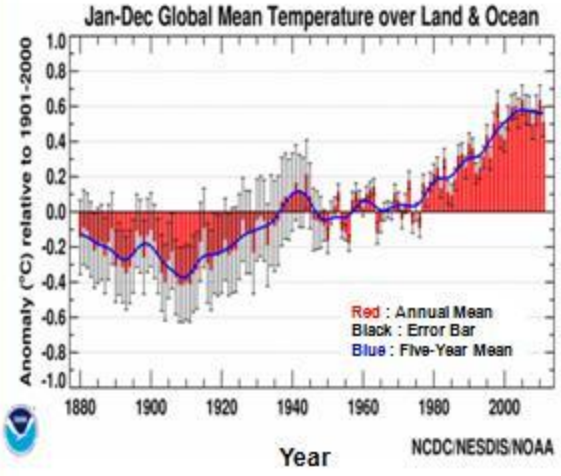
Regardless, the Army must be Prepared for these Missions that will grow in Frequency, Scale, and Complexity

2013 Army Science Board

Natural Variations of the Weather Obscure CC

- Weather is the day-to-day change occurring in the environment
- Climate is the average of variations of weather in an area over a long period

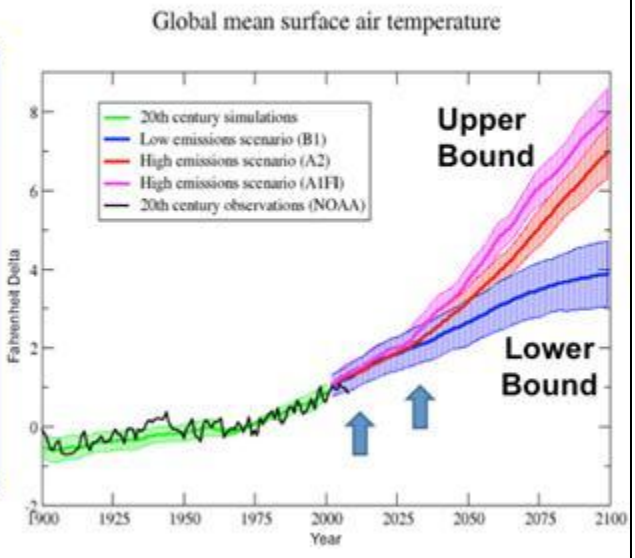
- IPCC confirms global temperatures and greenhouse-gas (GHG) content in atmosphere are increasing
- Likelihood of high-impact events (e.g., collapse of Western Antarctic Ice Sheet) by 2030 appears remote
- Climate conditions vary year by year owing to natural factors (e.g., El Niño, oscillations in the jet stream)
- Models indicate weather variability will increase (e.g., more severe storms)



2013 ARMY SCIENCE BOARD

Climate Trends to 2030 Foreseeable, Beyond 2030 Highly Uncertain

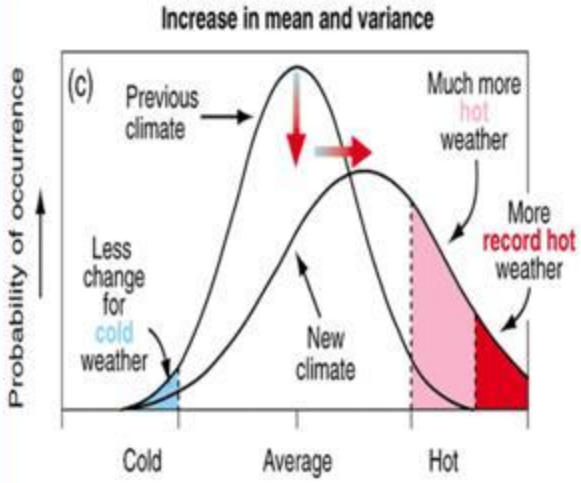
- Effects are generally a function of different scenarios for emissions of Greenhouse Gases (GHG)
- CC effects through 2030 are mostly determined by <u>current</u> GHG in the atmosphere
- After 2030, CC effects are expected to worsen due to increases in GHG



2013 ARMY SCIENCE BOARD

Increase in Temperature Mean and Variance Produces Extreme Weather

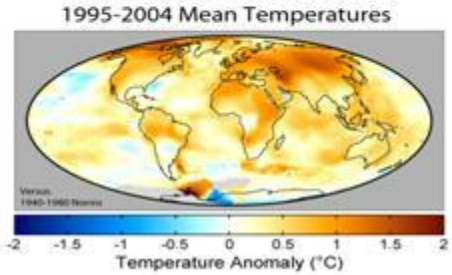
- **Temperature distribution for any location has an average and a variability**
- **Studies indicate mean will shift to higher temperature and variability will increase**
- **A shift in both mean and variability multiplies the extreme effects by dramatically increasing the probability in the distribution "tail"**
  - ***Example: 1°F shift and 0.1°F variability increase can nearly triple the # of extremely hot days***



2013 ARMY SCIENCE BOARD

#1. How well can relevant CC conditions in 2030 be predicted?

- Conditions vary geographically and are not uniform
- Predictability of specific effects (**weather**) in terms of magnitude, location and impact is low
- ***General trends*** in climate are predictable for several parameters
- Some values are predictable with high confidence



2013 ARMY SCIENCE BOARD

Finding: How well can relevant CC conditions by 2030 be predicted?

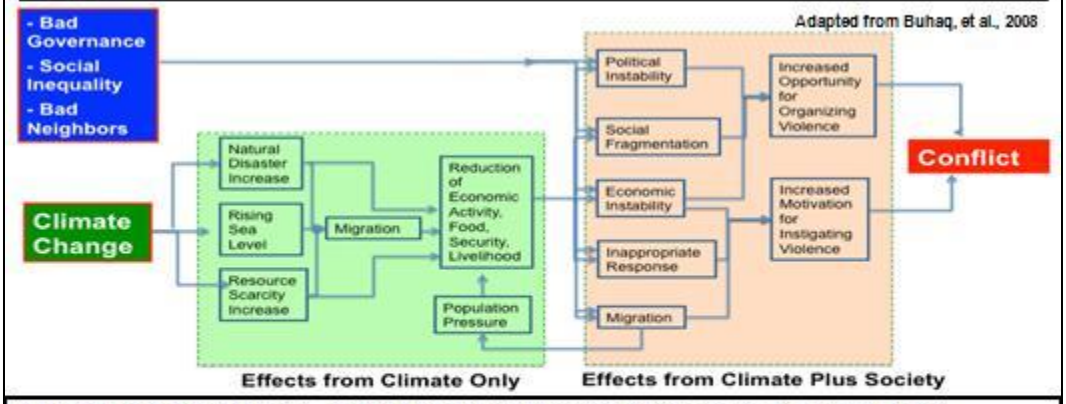
Environmental Parameter ("Stressors")	Predicted Overall Change by 2030	Impact On People and Environment	Impact on Army Operations
Severity of Tropical Cyclones	Slight Increase	**High**	**High**
Average Precipitation	Wet Areas Get Wetter; Dry Areas Get Drier	**Moderate**	**Moderate**
Heat Wave Events (human morbidity)	Localized Increases	**High**	**Moderate**
Average Surface Temperature	Increase by 0.3 to 0.4 Degrees Centigrade	**Moderate**	**Low**
Frequency of Tropical Cyclones	Slight Decrease	**High**	**Moderate**
Sea Level Rise	Several Centimeters	**Varies (Tidal)**	**Low**
Flood Events	Localized Increases	**High**	**High**
Drought Events	Localized Increases	**Moderate**	**Low**

Source: IPCC AR4, 2007.

- Predictability of weather volatility by location and magnitude is low
- Increases in temperature and variability from the effects of CC have significant impacts on the frequencies of extreme weather

2013 Army Science Board

Climate Change Alone Will Not Cause Conflict



- "[CC] is never the sole cause … of large migrations, poverty or violence; it always joins with other economic, political and social issues …," *Buhag, Gleditsch & Theisen, World Bank Pub., 2008.*
- "CC alone is unlikely to trigger state failure in any state out to 2030, but the impacts will worsen existing problems—such as poverty, social tensions, environmental degradation, ineffectual leadership, & weak political institutions," *NIC Chair Thomas Fingar, Hearing, House Committee on Energy Independence and Global Warming, 2008.*

US can Reduce the Likelihood of Conflict through Engagement

2013 Army Science Board

#2. How might CC modify the way the Army fights and accomplishes its Title 10 functions?

#2a. How does CC modify warfighting?

#2b. How does CC modify other Primary Missions?

#2c. What Title 10 Functions are most impacted?

Warfighting Roles: Prevent, Shape, Win

Army's Primary Missions

- Conduct counterterrorism and irregular warfare
- Deter and defeat aggression
- Conduct stability and counterinsurgency operations
- Defend the homeland and provide support to civil authorities
- Project power
- Provide a stabilizing presence
- Conduct humanitarian, disaster relief and other operations
- Counter weapons of mass destruction
- Operate effectively in cyberspace and space
- Maintain a safe, secure and effective nuclear deterrent

CC impacts seven of the ten Primary Missions

Title 10 Functions

- Recruiting
- Organizing
- Supplying
- Equipping
- Training
- Servicing
- Mobilizing
- Demobilizing
- Administering
- Maintaining
- The construction, repair of equipment
- The construction, repair of real property

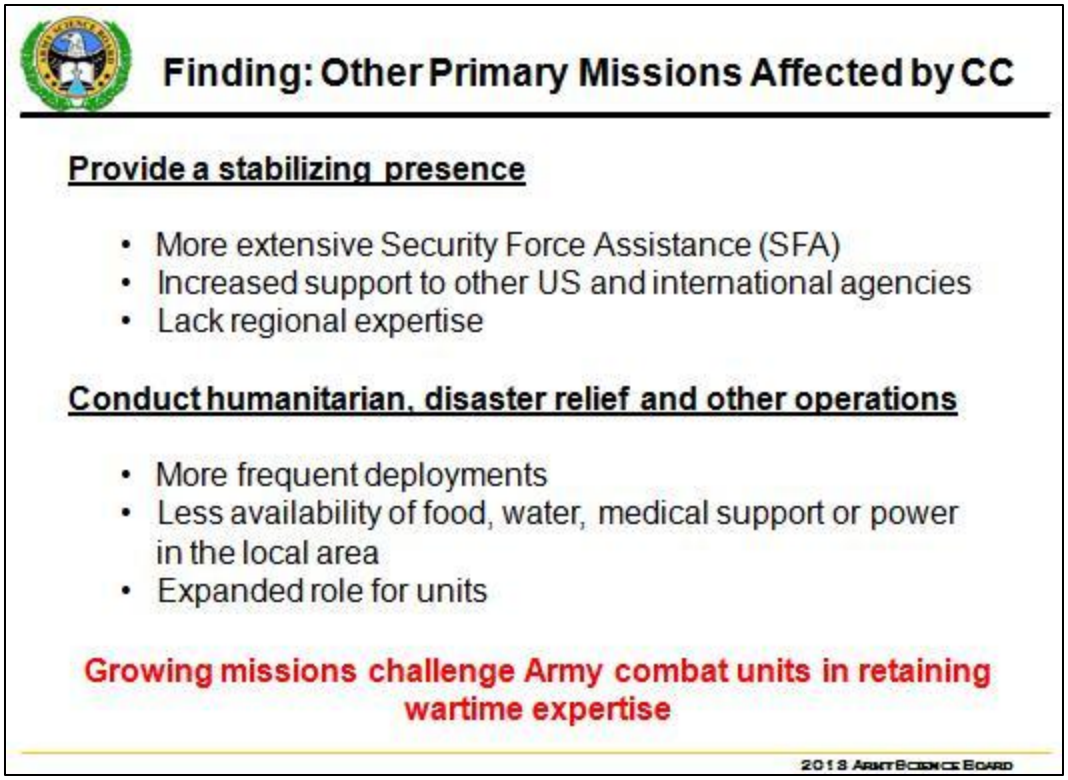
2013 Army Science Board

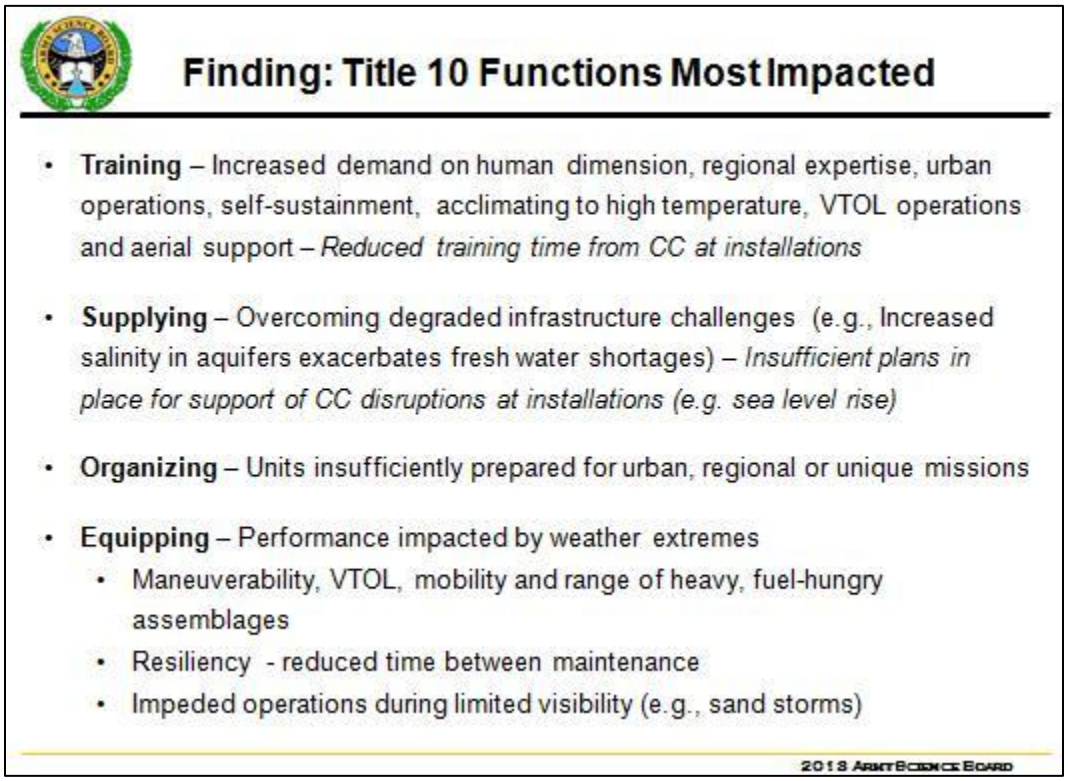
Finding: CC Modifies Warfighting

Increased Risk Areas caused by CC	Doctrinal Publications
• More need for strategic & tactical lift • Maneuver: more adverse conditions ➢ Heat, desert, storms, flooded areas • Logistics: marginal road network ➢ Distributed unit delivery challenged • Increased population in cities • Self-sustainment capabilities reduced • Support in Joint Operational Area (e.g., fires, ISR, aerial layer network)	• CC impacts not explicitly documented • Role of "WIN" discussed extensively • "PREVENT" and "SHAPE" roles not sufficiently developed to address expanded mission scope resulting from CC impacts

CC effects will challenge equipment capabilities

2013 Army Science Board


Finding: Other Primary Missions Affected by CC
Provide a stabilizing presence
• More extensive Security Force Assistance (SFA)
• Increased support to other US and international agencies
• Lack regional expertise
Conduct humanitarian, disaster relief and other operations
• More frequent deployments
• Less availability of food, water, medical support or power in the local area
• Expanded role for units
Growing missions challenge Army combat units in retaining wartime expertise
2013 Army Science Board


Finding: Title 10 Functions Most Impacted
• Training – Increased demand on human dimension, regional expertise, urban operations, self-sustainment, acclimating to high temperature, VTOL operations and aerial support – Reduced training time from CC at installations
• Supplying – Overcoming degraded infrastructure challenges (e.g., Increased salinity in aquifers exacerbates fresh water shortages) – Insufficient plans in place for support of CC disruptions at installations (e.g. sea level rise)
• Organizing – Units insufficiently prepared for urban, regional or unique missions
• Equipping – Performance impacted by weather extremes
• Maneuverability, VTOL, mobility and range of heavy, fuel-hungry assemblages
• Resiliency - reduced time between maintenance
• Impeded operations during limited visibility (e.g., sand storms)
2013 Army Science Board

Finding: Ensure CC Adaptations are Appropriate after 2030

- **Have a HQDA level body (e.g. Senior Sustainability and Energy Council):**
  - Establish policy to address CC for both the operating and generating forces
  - Incorporate climate change considerations into existing Army plans and planning processes (e.g., stationing, disaster response plans, real property master plans, critical infrastructure assessments)
  - Monitor progress and identifies gaps and impacts for periodic reports to Army leadership
- **TRADOC should establish CC as an essential factor in the Concepts to Capabilities Development Process**

CC effects will increase after 2030

2013 Army Science Board

Principal Recommendations (1 of 4)

1. **TRADOC/ARCIC:** identify and codify the CC impacts on the Army in the next updates of its doctrinal publications and its Capabilities Based Assessments
2. **TRADOC/ARCIC, ICW NGB, and OCAR**: improve effectiveness of humanitarian and stability operations by:
   - Designing specially tailored forces equipped and trained for these operations whose lift requirements and footprint are reduced.
   - Training specially trained functional unit "plugs" for quick response
   - Assigning all or a portion of the missions to the Army National Guard and Army Reserves with consideration of increased Title 32 missions due to CC

2013 Army Science Board

Principal Recommendations (2 of 4)

3. **ASA(ALT), HQDA G3/G4, TRADOC, AMC:**
   - Acquire and field an interim unmanned VTOL program for evaluation by FY15
   - Initiate an unmanned VTOL Program of Record with the objective of obtaining the capabilities necessary for the 2030 environment. (See: FY2013 Report of Committee on Armed Services, US House of Representatives regarding HR1630)
   - Direct RDECOM to review its S&T portfolios for potential applications to mitigate the effects of climate change and report results before FY15
   - Review Acquisition Programs that have not reached Milestone C and determine if CC materially affects system performance requirements

Principal Recommendations (3 of 4)

4. **HQDA G3 and TRADOC:** determine and implement a program on how units can be trained to work with similar, or representative, entities of government agencies or NGOs

5. **FORSCOM, ICW NGB, and OCAR:** enable and establish annual training events, between units and like entities with allied military, other governmental agencies and NGOs to develop more coordinated and comprehensive approaches to humanitarian and stability operations

Principal Recommendations (4 of 4)

6. **HQDA G3:** ensure CC adaptations are appropriate for climate conditions after 2030. Ensure the HQDA level coordinating body:

- Establishes policy to address CC for both the operating and generating forces
- Incorporates climate change considerations into existing Army plans and planning processes (e.g., stationing, disaster response plans, real property master plans, critical infrastructure assessments)
- Monitors the progress and identifies gaps and impacts for periodic reports to Army leadership

7. **TRADOC:** establish CC as an essential factor in the Concepts to Capabilities Development Process

2013 Army Science Board

S&T Areas to Mitigate Effects of CC on Army Operations

Preliminary List of S&T Areas and Applications

S&T Area	Application Example
Portable Water Purification Systems	Distributed Water Supply
Aerial Weather Sensors	Increased Wx Predictions
Improved Vision Sensors	Night and Dust Storms
Advanced Battery Power	Reduced Deploy Weight
NextGen Power Systems	Emergency Power
Renewable Power Sources • Wind • Solar PV	Reduced Reliance on Fuel-Driven Systems
Modular Shelter Systems	Temporary Housing
Unmanned Systems • Ground • Aerial	Reduce Vulnerability; improve efficiency
Turbine Engines	Improved Helicopter Engine Resilience

Technologies are applicable to both warfighting and humanitarian operations

2013 Army Science Board

APPENDIX D: SELECTED BIBLIOGRAPHY

Anderson, Craig. "Heat and Violence." *Current Directions in Psychological Science.* 10.1 (Feb 2010).

Anderson, G. B and M.L. Bell. "Heat Waves in the United States: Mortality Risk During Heat Waves and Effect Modification by Heat Wave Characteristics in 43 US Communities." *Environmental Health Perspectives*. 119.2 (2011): 210.

Basu, R. "High Ambient Temperature and Mortality: A Review of Epidemiologic Studies from 2001 to 2008." *Environmental Health*. 8.1 (2009): 40.

Buhaug, Halvard, Nils Petter Gladitsch, and Ole Magnus Theisen. "Implications of Climate Change for Armed Conflict." *Social Dimensions of Climate Change*. World Bank Workshop. The World Bank, Washington, DC. 5-6 March 2008. Presentation.

Dobransky, Steve. "Military Security, Energy Resources, and the Emergence of the Northwest Passage: Canada's Arctic Dilemma." *American Diplomacy.* Web. June 2008.

Fingar, Thomas. Cong. House. Committee on Intelligence. Committee on Energy Independence and Global Warming. *National Intelligence Assessment on the National Implications of Global Climate Change to 2030*. Washington. June 2008. Print.

"Fragile States." *Pulitzer Center on Crisis Reporting.* Pulitzer Center, n.d. Web. 2 January 2013.

Freier, N., S. S. Kostro, J. Guy, C. Buzzard, S. Eaton, and M. Loney. "Beyond the Last War: Balancing Ground Forces and Future Challenges Risk in USCENTCOM and USPACOM." *Center for Strategic & International Studies.* 30 Apr 2013. Web.

Gosling, S. N., G. R. McGregor, and J. A. Lowe. "Climate Change and Heat-Related Mortality in Six Cities Part 2: Climate Model Evaluation and Projected Impacts From Changes in the Mean and Variability of Temperature with Climate Change." *International Journal of Biometeorology*. 53.1 (2009): 31-51.

Jonassen, R., M. Canes, M. Daigle, and J. Alcorn. *Climate Change: What You Can Do Now.* Mclean, VA: LMI (2012).

Hix, W. "The Intellectual Leads the Physical." Army Science Board. Ft. Eustis, VA. 27 Feb 2013. Address.

Hsiang, Solomon, Marshall Burke, and Edward Miguel. "Quantifying the Influence of Climate on Human Conflict." *Science* 341.6151 (2013).

Karl, Thomas R. "NOAA's Temperature Records: A Foundation for Understanding Global Warming." U.S. Capitol Visitor Center, Washington, DC. 6 May 2010. Briefing.

McElroy, M. and J. Baker. "Climate Extremes: Recent Trends with Implications for National Security." Social Science Workshop on Societal Impacts of Near-Term Climate Stress. Columbia University, NY. 16-17 November 2011. Presentation.

McGrady, ED, M. Kingsley, and J. Stewart. *Climate Change: Potential Effects on Demands for US Military Humanitarian Assistance and Disaster Response.*CNA: (Nov 2010).

"National Security Implications of Climate Change for U.S. Naval Forces" Committee on National Security Implications of Climate Change for U.S. Naval Forces Naval Studies Board Division on Engineering and Physical Sciences, 2011.

Neal, D. and L. Wells II. *Capability Development in Support of Comprehensive Approaches: Transforming Internation Civil-Military Interactions*. CreateSpace (Jun 2012).

Pachauri, R.K. and A. Reisinger, eds. *Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Geneva, Switzerland: IPCC (10 June 2102).

Pederson, P., D. Dudenhoeffer, S. Hartley, and M. Permann. *Critical Infrastructure*

Interdependency Modeling: A Survey of US and International Research. Idaho Falls, ID: INL (Aug 2006).

Peng, R. D., J. Bobb, C. Tebaldi, L. McDaniel, M. Bell, and F. Dominici, F. "Toward a Quantitative Estimate of Future Heat Wave Mortality Under Global Climate Change." *Environmental Health Perspectives.* 119.5 (2011): 701.

Radakovic, S. S., J. Maric, M. Surbatovic, S. Radjen, E. Stefanova, N. Stankovic, and N. Filipovic. "Effects of Acclimation on Cognitive Performance in Soldiers During Exertional Heat Stress." *Military Medicine.* 172.2 (2007): 133-136.

Schwartz, P. and D. Randall. "An Abrupt Climate Change Scenario and Its Implications for United States National Security." Defense Technical Information Center. Oct 2003.

Sheridan, S. C., A. Kalkstein, and L. Kalkstein. "Trends in Heat-Related Mortality in the United States, 1975–2004." *Natural Hazards.* 50.1 (2009): 145-160.

United States. *The US Army Capstone Concept, TRADOC Pam 525-3-0*. Washington, DC: HQDA (2012).

___ *The US Army Capstone Concept, Army Doctrinal Publication-1*. Washington, DC: HQDA (2012).

___ Army Science Board. *Strengthening the Sustainability and Resiliency of a Future Force.* Washington: 2011.

___ Cong. House. "House Report 113-102. 113th Cong. Washington, GPO: 2013.

___ *Stability Operations, FM-3*-07. Washington, DC: HQDA (2008).

___ *U.S. Army Mission Command Strategy FY 13-19.* Washington, DC: HQDA (2013).

___ *Multi-Service Techniques for Civil Affairs Support to Foreign Humanitarian Assistance, ATP 3-57.20*. Washington, DC: HQDA (2013).

___ *Defense Planning Guidance*. Washington, DC: DOD (Jan 2013).

___ *Trends and Implications of Climate Change for National and International Security*. Defense Science Board Task Force. Washington, DC: DOD (2011).

___ *Army Planning Guidance*. Washington, DC: HQDA (Sep 2012).

___ *Support to Foreign Disaster Relief: Handbook for JTF Commanders and Below*. Washington, DC: DOD (Jul 2011).

___ Executive Office of the President. *The President's Climate Action Plan*. Washington, DC (Jun 2013).

___ DOD Science Board. *Challenges to Military Operations in Support of U.S. Interests*. Washington, D.C. (Dec 2008).

___ Department of Homeland Security. *2011 Critical Infrastructure Partnership Advisory Council Annual Report*. Washington, DC (2011).

Walker, Keith. "Army in Transition." AUSA. 22 May 2013. Address.

Walker, P., J. Glassner, S. Kambli. *Climate Change as a Driver of Humanitarian Crises and Response.* Somerville, MA: Feinstein International Center (2012).

Watts, J. D. and L. Kalkstein. "The Development of a Warm-Weather Relative Stress Index for Environmental Applications." *Journal of Applied Meteorology.* 43.3 (2004): 503-513.